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TOXICOLOGY INVESTIGATION

Wartime Toxicology: Evaluation of a Military Medical Toxicology Telemedicine Consults Service to Assist Physicians Serving Overseas and in Combat (2005–2012)

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Abstract Those medical providers deployed to remote countries and tasked with caring for military personnel must diagnose and treat diseases and nonbattle injuries that result from exposures rarely seen in developed countries. Military providers must also function with limited resources and a lack of access to physician specialists, to include medical toxicologists. There have been limited published approaches to addressing this clinical gap for medical toxicology. To address this void, the US Army Medical Department deployed an electronic mail telemedicine system to provide teleconsultations for remote health-care providers worldwide, including Iraq and Afghanistan. This study aimed to describe the types and the frequency of toxicology teleconsultation and consultant responses using electronic mail to assist physicians serving in resource-limited locations. This was a retrospective observational study in which an unblinded data extractor independently reviewed all medical toxicology email consultations. Using a previously developed data collection worksheet, the extractor recorded the type of question asked by the consultant (overdose case, envenomation, occupational exposure, etc.) and the duration of time from when the teleconsultation was placed until the consultant replied. The extractor also recorded if the patient was adult or pediatric and if the patient was US military, US contractor, or local national. The extractor also recorded how often the toxicologist provided the consulting physician with information, resources, or protocols to aid in the management of future cases. In addition, for clinical teleconsultations, the extractor documented the frequency that the consulted toxicologist (i) provided a differential diagnosis or specific diagnosis, (ii) provided specific management guidelines for a patient, and (iii) recommended to evacuate or not evacuate a patient. The results were analyzed using descriptive statistics. Of the 99 consultations evaluated, the most common consultation was for snake envenomation and antivenom recommendations (n=23, 23 %) followed by accidental chemical exposures (n=14, 14 %), drug testing (n=13, 13 %), and substance abuse (n=10, 10 %). In 41 % of consults, the toxicologist provided a differential diagnosis or specific diagnosis, and in 60 % of cases, the toxicologist provided specific management or evaluation guidelines. In 11 % of cases, the toxicologist recommended for or against evacuation of the patient. In 25 % of consults, the toxicologist provided the consulting physician with information, resources, or protocols to aid in the management of future cases. The most frequent consultations for the military telemedicine consultation service were for direct patient cases, specifically snake envenomation management and accidental chemical exposures. Our results may be used to educate physicians prior to military deployment or international humanitarian efforts and to create toxicology clinical

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guidelines for remote locations. Expansion of the current military teleconsultation program capabilities to include video teleconsultation may improve the effectiveness of military medical toxicology teleconsultation.

Keywords Toxicology · Military · Teleconsultation · Deployment · Remote

Introduction

Throughout American history, the majority of US military wartime casualties have occurred not from combat injuries but from disease and nonbattle injuries [1]. Those medical providers deployed to remote locations to care for military personnel must diagnose and treat diseases and nonbattle injuries that result from exposures rarely seen in developed countries [2]. These providers have limited resources and lack access to physician specialists, including medical toxicologists. To address this void, the US military created and deployed an electronic mail telemedicine system in 2004. This program provided (and continues to provide) teleconsultations for US military and government health-care providers serving throughout the world, including Iraq and Afghanistan. The program was limited to email (with audio and visual attachments) due to the narrow bandwidth communications available where deployed physicians were serving. Military medical toxicologists began providing teleconsultation through this service in July 2005 [3].

The objective of our study was to describe the types and the frequency of toxicology teleconsultations and consultant responses obtained between the years of 2005 and 2012 through the military telemedicine service.

Methods

Design This was a retrospective observational study. The study was reviewed by our local Institutional Review Board and deemed exempt from continuing review.

Population In 2004, the Army Medical Department (AMEDD) approved the use of the Army Knowledge Online (AKO) electronic mail system for dermatology teleconsultations. Given the success of this program, it was expanded to other specialties, including medical toxicology, in July 2005. The vast majority of teleconsultations originated from military medical providers operating in southwest Asia (Iraq, Kuwait, and Afghanistan), but the system was made available to all Public Health Service and Federal Emergency Management Agency health-care professionals during Hurricane Katrina relief efforts [4]. All patients for whom the AKO system was used were included in the analysis, regardless of location or status (military, contractor, or local national).

Data Source The AKO system is not encrypted; therefore, in order to comply with Public Law 104-191, Heath Insurance Portability and Accountability Act (HIPAA), teleconsultations could not contain Protected Health Information (PHI). Consulting medical providers generated all toxicology teleconsultations by sending an email to an established toxicology consult email address. The email was automatically received by the approximately eight toxicologists participating in the program and the AKO program manager. Toxicologists replied to the consults on an ad lib basis. The program manager ensured HIPAA compliance was maintained in all teleconsultations, and a toxicologist responded to the teleconsultation within a 24-h mandated time period. The program manager also collected program metrics for routine command oversight [4].

Variables and Data Collection An unblinded data extractor (board-certified emergency physician), not associated with the teleconsultation program, independently reviewed all de-identified medical toxicology email teleconsultations. No teleconsultations placed to the toxicology service were excluded from analysis.

Using a previously developed handwritten data collection worksheet, the extractor recorded the type of question asked by the consultant (overdose case, envenomation, occupational exposure, etc.) and the duration of time from when the teleconsultation was placed until the consultant replied. The extractor also recorded where the teleconsultation originated from and if it was clinical (i.e., involved a patient) or nonclinical. For all clinical teleconsultations, the extractor recorded if the patient was adult or pediatric and if the patient was US military, US contractor, or local national. If the patient was a local national, the extractor recorded his/her nationality. The extractor also recorded how often the toxicologist provided the consulting physician with information, resources, or protocols to aid in the management of future cases. In addition, for clinical teleconsultations, the extractor documented the frequency that the consulted toxicologist (i) provided a differential diagnosis or specific diagnosis, (ii) provided specific management guidelines for a patient, and (iii) recommended to evacuate or not evacuate a patient.

Analysis The exposures were characterized using descriptive statistics. Given the teleconsultation program has continued to operate since this data was collected in 2012 making the data presented in the study a sampling of the overall program, 95 % confidence intervals were used. The 95 % confidence intervals were calculated using the Wilson procedure [5].

Results

Ninety-nine teleconsultations were performed from July 2005 to December 2012. The average duration of time from when the consulting medical provider sent the teleconsultation until the toxicologist replied was 3 h and 46 min (range 0.06 to 29.18 h). The majority of teleconsultations originated from Iraq and Afghanistan (Table 1). The most common teleconsultation was for snake envenomation and antivenom recommendations (n=23, 23 %; 95 % CI 16 to 32 %) followed by accidental chemical exposures (n=14, 14 %; 95 % CI 9 to 23 %), drug testing (n=13, 13 %; 95 % CI 8 to 21 %), and substance abuse (n=10, 10 %; 95 % CI 6 to 18 %). Other teleconsultations were for intentional overdoses, scorpion envenomations, occupational exposures, and withdrawal syndromes (Table 2).

Seventy-seven (78 %; 95 % CI 69 to 85 %) teleconsultations were clinical (involved a patient) and 22 (22 %; 95 % CI 15 to 31 %) were nonclinical. The 77 clinical teleconsultations included 59 (77 %; 95 % CI 66 to 85 %) US military patients, 4 (5 %; 95 % CI 2 to 13 %) US contractors, and 14 (18 %; 95 % CI 11 to 28 %) local nationals (nine Afghani, five Iraqi). Seven of the local national patients were pediatric (less than 18 years old). Of the seven pediatric exposures, three were for snake envenomations (all Afghani children), and four were for accidental chemical exposures (one Iraqi child, three Afghani children). The 22 nonclinical teleconsultations focused on anticipation of potential toxicological hazards and availability of therapies. Of the nonclinical teleconsultations, 13 (59 %) were regarding potential risk of snake envenomations (i.e., what venomous snakes are endemic to a given area) and antivenom availability (Table 2).

With regard to the 77 clinical teleconsultations, the toxicologist provided a differential diagnosis or specific diagnosis in 41 (53 %; 95 % CI 42 to 64 %) and provided specific management or evaluation guidelines for a patient in 60 (78 %, 95 % CI 67 to 86 %). In 11 of the clinical teleconsultations (14 %: CI 8 to 24 %), the toxicologist recommended for or against evacuation of the patient (seven recommendations for evacuation and four recommendations against evacuation). In 25 of the overall 99 teleconsultations (25 %: CI 18 to 35 %) the toxicologist provided the consulting physician with information, resources, or protocols to aid in the management of future cases. In nine (9 %: CI 4 to 16 %) of the teleconsultations, the toxicologist did not provide a diagnosis, recommendations, or resources. Those nine questions included identification questions (i.e., is this substance in the picture a synthetic cannabinoid), teleconsultations regarding rashes in which the toxicologist deferred to the dermatologist to answer the clinical question, or questions with a simple affirmative or negative answer (i.e., do military-issued gas masks protect against chlorine gas).

Table 1 Toxicology teleconsultation location of origin

Location of origin	Number	Percentage (confidence intervals)
Iraq	43	43 % (34–53 %)
Afghanistan	37	37 % (28–47 %)
Kuwait	5	5 % (2–11 %)
Qatar	4	4 % (2–10 %)
Continental USA	4	4 % (2–10 %)
Naval vessel	2	2 % (1–7 %)
Djibouti	2	2 % (1–7 %)
Germany	1	1 % (0–5 %)

Discussion

We found that the majority of teleconsultations originated from Iraq or Afghanistan. This was expected given these were the major theaters of operation for the US military during the 2005 to 2012 time frame. The majority of teleconsultations were clinical; however, nearly a quarter of teleconsultations were nonclinical. The most common teleconsultation was regarding snake and/or antivenom recommendations; however, fewer than half of those consultations were for actual patient exposures. This finding is likely due to military physicians ensuring they were prepared for the threat of a possible snake envenomation.

While the primary focus of the deployed military physicians was the military personnel assigned to their care, three of the ten envenomations were for Afghani children while there were no Iraqi pediatric snake envenomations. While the venomous snake species present in Afghanistan and Iraq are similar, the substantially more robust Iraqi health-care system may have accounted for the disparity of utilization of US medical care by local nationals. Further future studies may aid in predicting what extent a local population may depend upon US medical assets and assist military planners in responding accordingly.

Though local nationals included a small percentage of the teleconsultations, they presented unique challenges beyond envenomations. One such teleconsultation involved a 17-year-old Iraqi national who presented with altered mental status, ataxia, and decreased strength with wrist extension after drinking an unknown liquid. The toxicologist consulted made the diagnosis of lead poisoning and recommended chelation with dimercaprol and ethylenediaminetetraacetic acid. The diagnosis was later confirmed when the fluid consumed was found to be tetraethyl lead. Other unique poisoning teleconsultations reviewed in our study include organophosphate, cobra venom, sulfur mustard, and chlorine gas. These teleconsultations illustrate challenging patients where

Table 2 Toxicology teleconsultation question categories

Type of exposure	Total teleconsultations *N*=99 (%; 95 % CI)	Clinical teleconsultations *N*=77 (%; 95 % CI)	Nonclinical teleconsultations *N*=22 (%; 95 % CI)
Snake/snake antivenom (percentage; CI)	23 (23 %; 16–32 %)	10 (13 %; 7–22 %)	13 (59 %; 39–77 %)
Accidental chemical exposure (percentage; CI)	14 (14 %; 9–22 %)	12 (16 %; 9–25 %)	2 (9 %; 3–28 %)
Drug testing (percentage; CI)	13 (13 %; 8–21 %)	13 (17 %; (10–27 %)	
Substance abuse (percentage; CI)	10 (10 %; 6–18 %)	8 (10 %; 5–19 %)	2 (9 %; 3–28 %)
Intentional overdoses (percentage; CI)	8 (8 %; 4–15 %)	8 (10 %; 5–19 %)	
Scorpion envenomations (percentage; CI)	8 (8 %; 4–15 %)	8 (10 %; 5–19 %)	
Occupational exposures (percentage; CI)	7 (7 %; 3–14 %)	7 (7 %; 4–18 %)	
Withdrawal syndrome (percentage; CI)	3 (3 %; 1–9 %)	3 (4 %; 1–11 %)	
Other/unknown (percentage; CI)	13 (13 %; 8–21 %)	8 (10 %; 5–19 %)	5 (23 %; 10–43 %)

deployed physicians and patients may benefit from a medical toxicologist's expertise.

Interestingly, while Afghanistan is the world's largest producer of heroin, none of the consultations were for indigenous opiate exposure [6]. This may be due to infrequent abuse by military personnel, fear of punishment if abuse was identified during random or command-directed urine drug screening, or US-trained physician familiarity with opioid exposure. Several consultations were regarding synthetic cannabinoids indicating some military personnel were attempting to use mind-altering substances for which the military at the time did not routinely screen for during urine drug testing.

Beyond the benefit of the teleconsultation on a single case, the information obtained from these teleconsultations can assist in the development of toxicology education programs for military medical providers and other providers in overseas humanitarian or combat operations [3]. For example, while antivenom guidelines for deployed locations have been developed and disseminated, the frequency of teleconsultation on this topic suggests that deployed physicians were unaware of their existence indicating the need for improved distribution. Alternatively, the antivenom guidelines may have failed to address the providers' questions prompting the need for revisions and improved training.

A potential area of improvement for our teleconsultation program is the response time. Poisoning is frequently an acute disease requiring acute intervention. The average time to reply of 3 h 46 min is inadequate for some acute poisoning emergencies. For example, in a case of organophosphate poisoning, the toxicologists responded in 42 min, and while the patient did well, a 42-min delay in recommending atropine administration could prove fatal in a more severe exposure. With the current AKO teleconsultation program, the time to teleconsultation is limited by the frequency at which the consultants review their emails. With the development of secure email communication via cellular phones, response time could be significantly decreased for acute teleconsultations. The development of a triage system could aid providers in obtaining emergency teleconsultation when necessary. Simply calling the consultant by phone with an electronic message that an emergency consult has been placed could reduce the response time to minutes. In addition, as broadband communication becomes increasingly available throughout the world, live video teleconsultation may provide the toxicologist the ability to view the patient, electrocardiograms, and other pertinent visual items.

The US military has successfully used the AKO teleconsultation service in remote locations [3, 4, 7–9]. Other studies have demonstrated the effectiveness of similar programs for other medical specialties [10, 11]. In the future, the development of a civilian medical toxicology teleconsultation service to assist both local and volunteer physicians in locations with limited subspecialty care may aid in reaching those in greatest need. Furthermore, while studies have demonstrated the effectiveness of poison centers and medical toxicology consultation services, expansion of toxicologists' teleconsultation capabilities to include electronic main, texting, and video consultation may further improve resource utilization and patient outcomes [12–15]. Further studies are necessary to determine the feasibility and effectiveness of such programs.

Limitations

There were several limitations to our study. Due to the lack of patient identifiers in order to maintain HIPAA compliance, insufficient data were available to determine the impact of toxicology teleconsultation on patient outcomes. While this limitation existed, this study demonstrates that the medical toxicology teleconsultation did result in providing specific diagnoses and management recommendations in the majority of cases. Future studies with outcome measures and a comparison group may clearly demonstrate the impact email-

based teleconsultation has on patient outcomes and resource utilization. Furthermore, demographic information about the teleconsultations was limited to only that information provided by the consulting physician. In the future, the utilization of a standardized email format could provide more demographic information to medical toxicologists and researchers.

Threats to the internal validity of our study include that a single, unblinded abstractor performed the data collection and may have imposed bias when evaluating when the toxicologist assisted in a case. However, given the abstractor was trained, the inclusion criteria were clear, there were no exclusion criteria, important variables were defined for the abstractor, and a standardized abstraction form was used, this potential bias was likely minimized [16]. Furthermore, unlike a medical chart in which some information may not be documented, the extractors reviewed the actual emails, so no information that was communicated between the consulter and consultant was lost.

Threats to the external validity include that only teleconsultations placed via the AKO teleconsultation program were reviewed. Discussion with military medical toxicologists revealed that infrequently they do receive teleconsultations from deployed military physicians through routes other than the AKO teleconsultation program. However, the toxicologists report the majority of their teleconsultations occur via the AKO system. US poison centers have also received telephonic teleconsultations from military physicians operating in deployed locations, but this is an infrequent occurrence. Another threat to the external validity is the AKO teleconsultation program's patient population. The US military consists of predominately healthy, young adults with few medical or psychiatric disorders. This is significantly different from the general world population, particularly when compared to the frequent illicit drug users and suicidal patients that require toxicology expertise. In addition, while the majority of teleconsultations were replied to by the consultant within 4 h, consultants have up to 24 h to respond as directed by the AKO teleconsultation program manager. This potential for a delayed response may have resulted in medical providers not placing teleconsultations in acutely or critically ill patients. As such, our data may fail to reflect some of the more severely poisoned patients; however, one would expect a medical toxicology teleconsultation to have even greater value in these cases.

Conclusions

The most frequent teleconsultations for the military telemedicine consultation service were for snake envenomation management and accidental chemical exposures. Our results may be used to educate physicians prior to military deployment or international humanitarian efforts and to create toxicology clinical guidelines for remote locations. Similar cost-efficient, low-bandwidth programs should be considered to support the treatment of toxicologic emergencies in the developing world. Expansion of the current AKO teleconsultation program capabilities to include rapid response and video teleconsultation may improve the effectiveness of military medical toxicology teleconsultation.

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